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ABSTRACT

This module discusses methods of obtaining table salt from seawater. Topic areas considered include: (1) obtaining salt by solar evaporation of seawater in holes; (2) obtaining salt by boiling seawater in pots; (3) how table salt is obtained from seawater in the Philippines; and (4) methods of making salt by solar evaporation of seawater in the Philippines (such as using concrete ponds, polyethylene ponds, and bamboo rafts). Procedures (accompanied by illustrative diagrams) for using these methods are included. The method selected depends on the available materials, capital, and place for solar evaporation. (JN)

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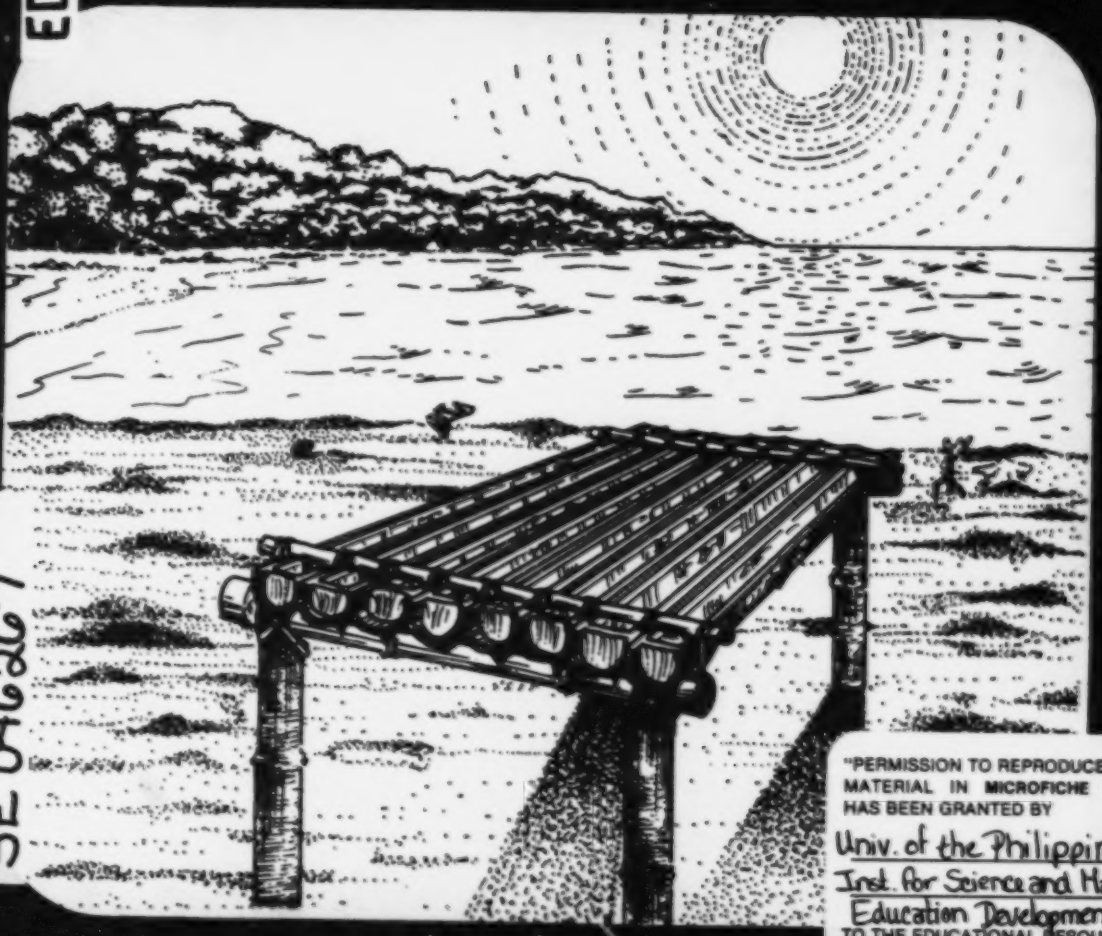
# What We Take From Our Environment



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# Table Salt from Seawater

## (Solar Evaporation)

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## TABLE SALT FROM SEA WATER

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# Table Salt from Seawater
## (Solar Evaporation)

Each gallon (about 4.5 liters) of seawater contains about 105 grams of table salt.[1] If the oceans of the world dried up there would be left at least 184 500 000 cubic kilometers of table salt. It would be about 14 1/2 times the size of the whole continent of Europe above the line where the high tide reaches.

Long ago man probably observed seawater in shallow holes on the shore disappear under the sun leaving behind salt. It probably seemed to him that it was the sun that "drew up" seawater leaving behind salt.

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[1] The name table salt is used for the salt, sodium chloride, used for cooking and other purposes to differentiate it from a class of chemical substances called salts.

Since he was not able to find an explanation, early man then believed salt was a gift from the sun god and it had sacred powers. It had the power to preserve food and the bodies of the dead.

How does your study of science in school explain how table salt is formed from seawater under the sun?

Different salts dissolve in seawater.[3] Only a certain amount of salt dissolves in a given volume of water at a given temperature. No more than this amount of salt can be dissolved in the water which we say is saturated with salt. The change of water from liquid to vapor is a process called evaporation. As the water in seawater evaporates, the volume decreases and the less soluble salts come out of the water as crystals. Different salts come out at different times as more water evaporates. The crystals sink to form layers at the bottom of the water. Salts in seawater crystallize with the least soluble coming out first in the following order of appearance: calcium carbonate ($CaCO_3$), calcium sulfate ($CaSO_4$), sodium chloride or table salt (NaCl), magnesium sulfate ($MgSO_4$), potassium chloride (KCl), magnesium chloride ($MgCl_2$).

## SALT BY SOLAR EVAPORATION OF SEAWATER IN HOLES

What early man observed at seashores, seawater drying up and leaving salt, made him think of a way to bring more seawater from the sea to land. He dug a canal from the seasore to deep holes made nearby.

[3]See the module *Potable Water From Sea Water by Solar Distillation (Part 1: Why is Seawater Salty?)*, Science Education Center, University of the Philippines, Quezon City.

At high tide, seawater filled the deep holes. At low tide, the seawater evaporated under the heat of the sun. Salt formed in the deep holes. The filling up with seawater at high tide and the drying up under the sun was allowed to continue until the water in the deep holes became saturated with salt. The salt that came out of the water was then collected.

This method of obtaining salt was only possible during a long hot dry period. Heavy rainfall added fresh water to the water in the holes which made evaporation and the forming of salt difficult.

**SALT BY BOILING SEAWATER IN POTS**

Man then thought of another way to obtain salt even during rainy days. He boiled seawater. Instead of the heat of the sun he used the heat of burning wood to evaporate seawater.

These two methods of obtaining salt from seawater perhaps developed at the same time in different parts of the world. Solar evaporation in natural deep holes near the sea were done in ancient Italy, Cape Verde and Caribbean Islands and in other hot regions.

It was found that salt free of dust and insects could be obtained if ponds instead of natural holes were used. These ponds had floors of clay or wood. This method was followed in France, Spain and Portugal.

Complicated equipment for the solar evaporation of seawater is now used in the United States, Bahamas, France and Africa. The methods are similar to the following:

In Northern European countries and in places where there are no long hot summer months, seawater is evaporated by boiling in pots. This method gives cleaner salt than by solar evaporation in ponds.

The Chinese have used this method thousands of years ago.

To obtain salt, early German tribes built fires using wooden logs. Then they sprinkled seawater over the burning logs. As the water evaporated, salt was left on the logs.

In some places of Thailand from early times to the present, seawater is sprinkled over hot rocks. Salt is scraped from the rocks when water evaporates.

Seawater is made to flow through a series of gates built of wood or a combination of wood and concrete into several shallow ponds separated by dikes. Water is made to evaporate until the mass per milliliter (density) of the seawater is 1.22 g per milliliter. At this density finely suspended matter in the water such as sand and clay as well as the less soluble salts, calcium carbonate ($CaCO_3$) and calcium sulfate ($CaSO_4$) come out of the solution. Freed of these matter, seawater is then made to flow into four crystallizing pans for producing table salt. The first and second pans still contain calcium sulfate with the salt that is formed. The salt removed from the third pan contains small amounts of magnesium sulfate ($MgSO_4$). The last pan gives almost pure salt which is used in industries.

## HOW IS TABLE SALT OBTAINED FROM SEAWATER IN OUR COUNTRY?

Our forefathers living by the seashore knew how to obtain salt from seawater. Some tribes still follow the methods used before the coming of the Spaniards.

The Mangyans of Mindoro[3], now living in the mountains, obtain salt using fire to evaporate seawater. In April, the percentage of salt in seawater is high, because the strong heat of the sun throughout the hot months of February to May evaporates a great amount of seawater. In April, the Mangyans go to the seashore near swampy areas where there are many trees. They spend about half a day cutting trees for enough fuel. The *bakhaw* or the *ampipinik* trees[4] give the best firewood.

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[3] Adapted from Postma Antcom S.V.D., Please Pass the Salt. *Filipino Heritage*, Book 2, pp. 486-488.

[4] Botannical names: *Bakhaw* (Rhizophora Spp); *Ampipinik* (Avicennia Sp).

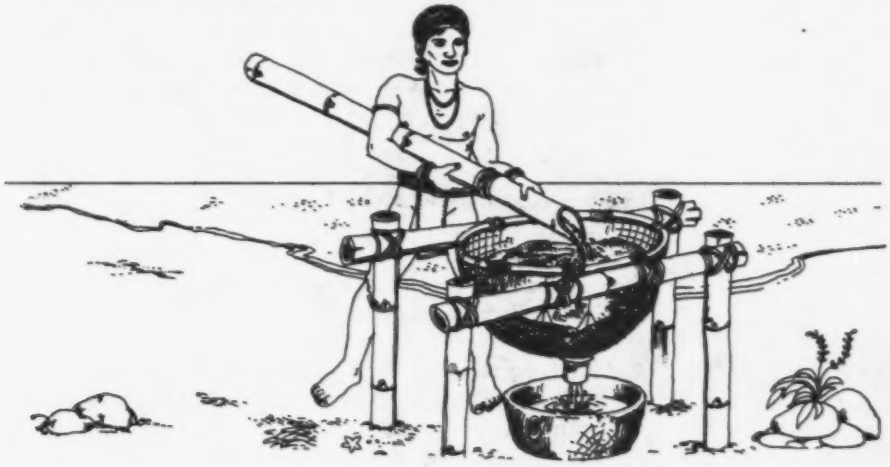
On the beach, they build piles of wood and set them on fire.

They use a long bamboo container to get seawater which they slowly pour on the strong fire. They pour the seawater at intervals so as not to put out the flames. They pour seawater on the fire until the wood is completely burned up.

They then collect the ashes and coal. They turn the big pieces of coal into powder using a heavy stone or wood.

Then they put the powdered ash and coal in a basket woven out of dried buri palms.

They pour in seawater to wash the salt out of the ashes. To prevent loss of the washings, they wrap the bark of the *anagyong* tree around the lower portion of the basket to form a funnel. They attach a bamboo tube to the funnel to lead the water into a big bark container.



Using half a coconut shell as a cup, they pour the filtered salt solution into a tree bark container. They evaporate the salt solution over a small flame to prevent burning of the bark. But as soon as a thin layer of salt covers the bottom of the container, they make the fire larger. There is no more danger of burning the bark. The salt takes in the heat from the bark preventing it from reaching a temperature at which it burns (kindling temperature).

When all the salt solution is evaporated, they repeat the washing of the ash and boiling of the salt solution. Washing and boiling is repeated about five times to remove all the salt from the ashes. Salt obtained by this process is gray in color and very impure as it contains soluble substances from ash.

The beginning of salt as an industry in our country dates back to 1583. Out of 63 provinces, 26 produce salt. The 1977 report of the National Census and Statistics Office (NCSO), gives the production of salt as 200 000 metric tons at a value of P77 434 610.

Salt is produced in the following provinces:

1. By solar evaporation of seawater; Batangas, Bulacan, Cavite, Cebu, Iloilo, Ilocos Sur, Occidental Negros, Oriental Negros, Palawan, Pangasinan, Rizal, Zamboanga.

2. By boiling seawater; Batangas, Cagayan, Camarines Norte, Ilocos Norte, Ilocos Sur, La Union, Leyte, Misamis, Pangasinan, Samar, Sorsogon, Surigao, Zamboanga.

Boiling seawater in big clay or iron containers is still carried out in Pangasinan and Ilocos provinces. The process can be carried out the whole year. Only a small amount of salt, can be produced within a period of time. The cost of firewood as fuel is expensive.

A combination of solar evaporation and boiling by fire is carried out by the Ceramar-Agro-Marine Industries in Barotoc Viejo, Iloilo province and in the Philippine Salt Company in Mindoro Province. A good grade of salt, 92.7% sodium chloride is produced but a big capital is needed to set up the project and the cost of production is high.

Industries that manufacture chemicals such as sodium hydroxide, chlorine, hydrochloric acid need very pure sodium chloride. At Tiwi, Albay, salt is commercially produced using steam to evaporate seawater. "Salt Phil" (Tabacalera) produces industrial salt by steam evaporation in vacuum pans. The salt produced are of 3 grades, 97.55%, 99.29%, and 99.73% sodium chloride.

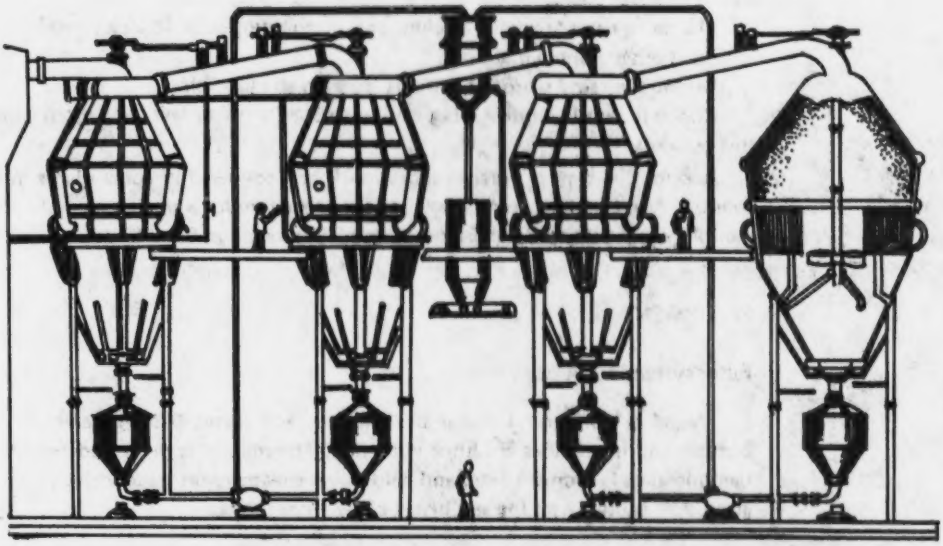
## METHODS OF MAKING SALT BY SOLAR EVAPORATION OF SEAWATER

Since fuel is expensive we will discuss the different methods used in our country to obtain salt by solar evaporation. The choice of the process depends on the available materials, capital and convenient place for solar evaporation.

**Salt by Solar Evaporation of Seawater in Concrete Ponds**

Rizal, Bulacan, Cavite and Iloilo are leading in salt production by solar evaporation in ponds.

With certain local modifications, the process is as follows. Salt is produced during the months from December to April.



INDUSTRIAL SALT BY STEAM EVAPORATION

The ponds are about 1.5 m x 2 m with board sides and tile or concrete bottoms. At high tides, seawater is trapped in a series of ponds. Seawater evaporates in each pond during low tide in the heat of the sun. As it flows from one pond to another more and more water is evaporated. When the volume becomes about 1/9 of its original one, the salt solution is allowed to crystallize in shallow ponds. The salt crystals are harvested at sunset. They are piled into heaps at the side of the ponds and allowed to drain for several hours. The salt is then gathered into baskets for further draining and drying in the sun. They are then stored in warehouses.

The salt is impure with calcium and magnesium salts. It also contains dirt, sand and other soluble materials.

During the rainy season the ponds are used to raise fish.

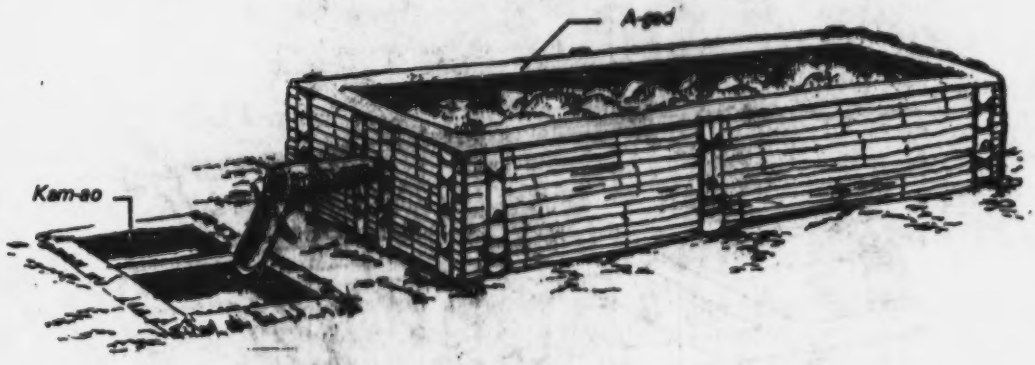
Concrete ponds require a big capital to start with so few people can go into this business.

A primitive way of solar evaporation is still followed in some places in the country. For example, in Miagao, Iloilo a procedure for a small scale industry is the following: Salt by Solar Evaporation of Seawater on Sand Beds.[5]

## EQUIPMENT

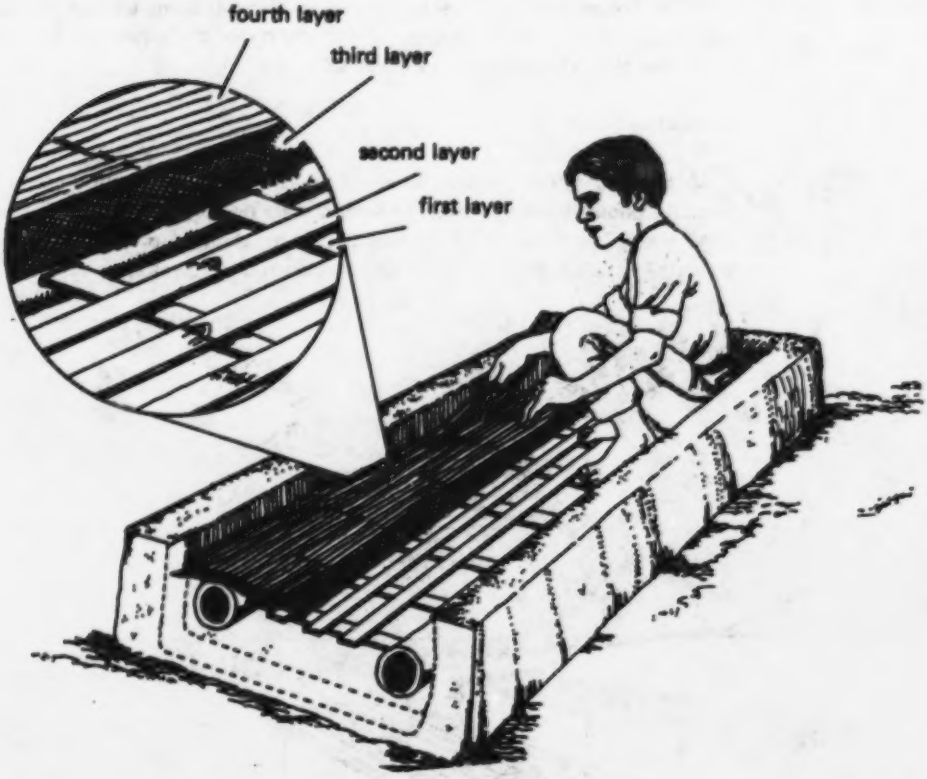
### Filter system or *"A-gad"*

A-gad is a mound 1 meter by 3 meters and about 0.30 meter high. The bottom and inner sides are lined with clay. The mound is protected outside by bamboo slats laid on the sides and held by narrow bamboo stakes driven into the ground. It is built near the salt beds farther from the sea.




[5] From the procedure described by Miagao fishermen salt makers.

It is made of four layers. The **first layer** is made of bamboo pieces laid crosswide to form a ladder-like support for the top layers. The **second layer** consists of bamboo slats placed over the first layer. The **third layer** are pieces of jute sack material laid over the second layer. The **fourth or top layer** of bamboo pulp (tadtad) formed by beating bamboo is placed over the jute sack. A movable drain pipe is fitted to the *"A-gad"* leading to the collecting bowl.




**Collecting bowl or *"Kam-ao"*** **(See page 10.)**

The "Kam-ao" is a 1 meter X 1 meter and about 1/2 meter high hole dug in the ground near the filter system. It is used to collect the filtered salt solution. The hole is divided into halves and the walls and bottom of each half are covered with clay collected from nearby streams or rivers used in pots which does not allow water to pass through. One half is used to collect the first filtrate of dilute salt solution; the other half to collect concentrated salt solution.

The "A-gad" and "Kam-ao" are protected from the sun and rain by a nipa roof. **(See page 15.)**

**Water collector or *"Bay-ong"***

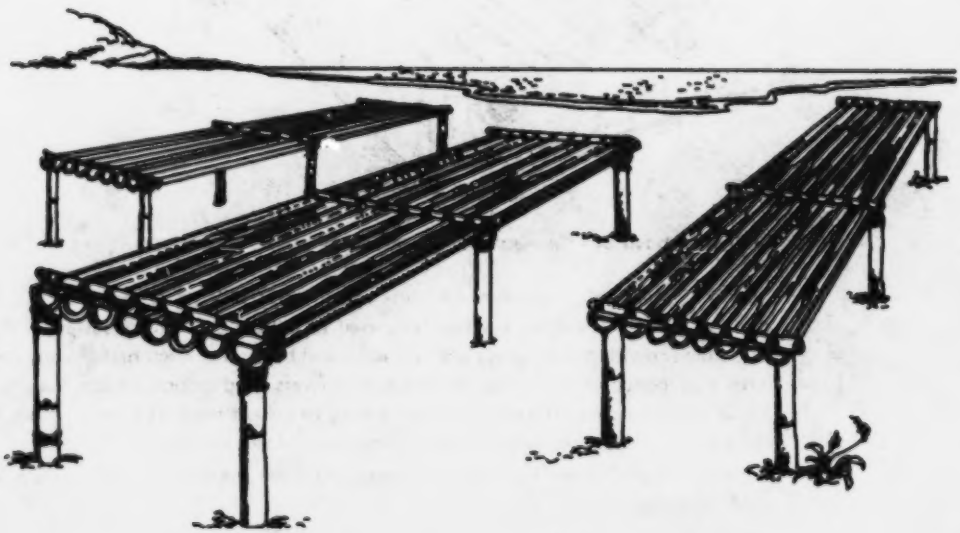
This is made of good sized bamboo about 6 meters long. It can contain about 18 to 22 1/2 liters (4-5 gallons) of seawater. (See page 14.).

**Shower head**

The shower head is a piece of bamboo, about 0.50 meter carefully bored with holes all over. It is attached to the mouth of the water collector. Water comes out from the holes like a shower. (See page 14.).

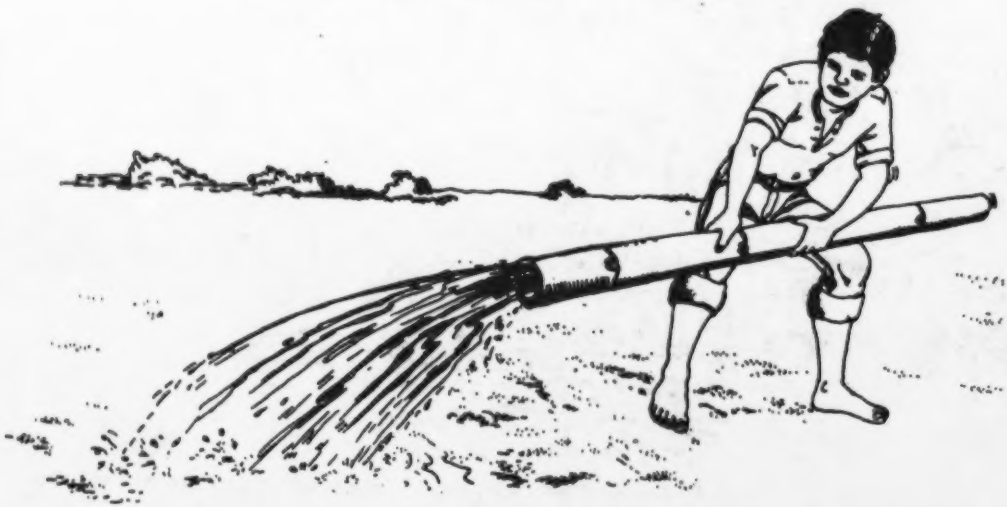
**Bamboo raft**

A bamboo raft 8 bamboo halves wide, is made with bamboo halves from bamboos about 8 meters long. The bamboos are tied together with thin bamboo skin strips. The raft is laid on bamboo posts about 1 meter high from the ground. The raft is built in a place which receives direct heat from the sun.



## PROCEDURE

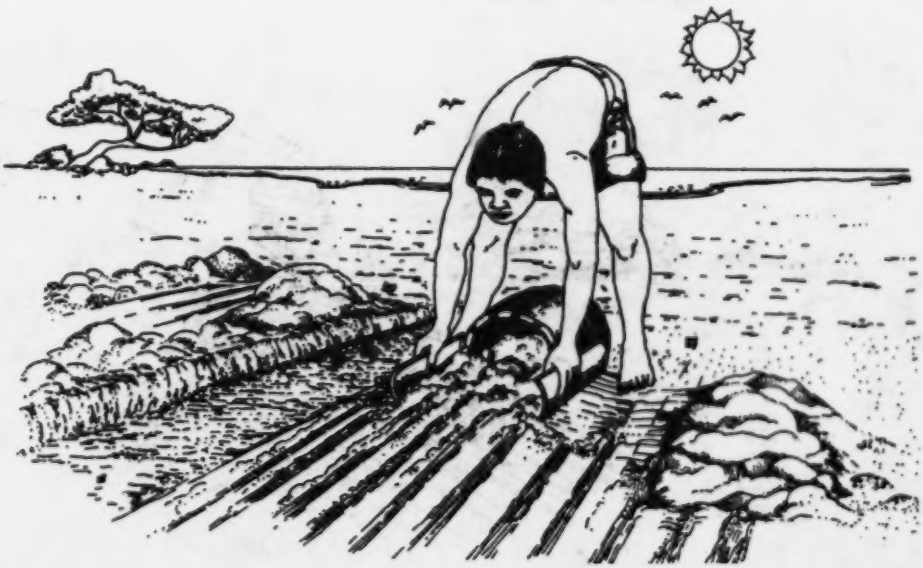
A good spot on the beach 4 meters by 8 meters not reached by high tide is cleared of stones and rubbish by flushing strongly with seawater contained in the water collector or "Bay-ong".



With a bamboo rake the wet sand is raked first horizontally and then vertically like an agricultural field.

The salt bed is watered at least 4 times a day with seawater using the water collector or "bay-ong" with shower head attached. After each watering it is again raked horizontally and vertically. For each filter system or *"A-gad"* at least 5 of these beds are set up. After 4-7 days of repeating these operations under the sun, salt concentrates on the sand beds.

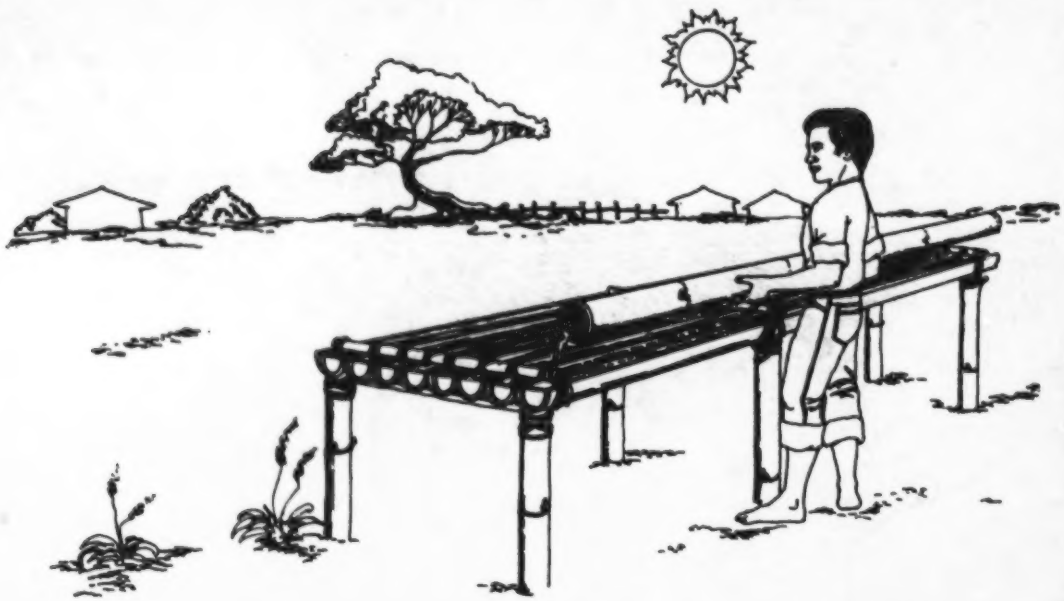
Using a bamboo scraper mounds of sand are formed on the sand beds. These are then collected in baskets and dropped into the filter system.



Seawater is then poured over the sand on the filter using long bamboo containers.

The filtrate is made to drip through the drain pipe into the collecting bowl (Kam-ao) built close to the filter system. Washing of the sand in the filter is continued until the salt solution that drops into the collecting bowl becomes clear. The filtered salt solution is scooped out from this bowl and poured back on the filter. The movable drain pipe is directed to the second half of the collecting bowl. The volume of the filtrate collected is made the same as the original one by adding more seawater through the filter if necessary. The salt solution is then tasted by an experienced saltmaker to determine if the salt concentration is enough for the evaporation stage. Otherwise, the salt solution is again filtered over more salty sand.

"Salingkuge" or "bolunos" (gugo in Tagalog), a kind of root is beaten to a pulp. It is then dipped into the filtrate and squeezed to get its juice. It is believed that the juice speeds up the formation of salt crystals.



The liquid is scooped out and put into the bamboo collector or "bay-ong". A filter made up of dried, fibrous epidermal coverings of palm leaves is inserted in the open end to remove sand and other impurities. The filtrate is poured into the bamboo rafts for evaporation under the sun. It takes a whole day to evaporate the filtrate depending on the weather. Using a bamboo scraper the dry salt is scraped from the raft in the afternoon. About 10-12 gantas of salt are collected each day from the rafts. The salt is bartered within the community and the rest sold at P1.00/ganta.

The method is claimed to have the following advantages:

1. The set-up is easy and economical to build, needing only a small capital.
2. Materials found in the area are mainly used. These materials are also found in many places.
3. There is no expense to maintain the set-up. It can be stored and used in the next dry season.
4. The salt produced has white and good sized crystals.
5. The set-up does not occupy much space and can be set up even in small areas in a good sandy beach.
6. The method is high yielding.

A procedure for a small scale industry was devised by Simeona M. Aypa, Bureau of Fisheries and Aquatic Resources in 1977. The process is as follows:

**Salt By Solar Evaporation Of Seawater Using Polyethylene Ponds**

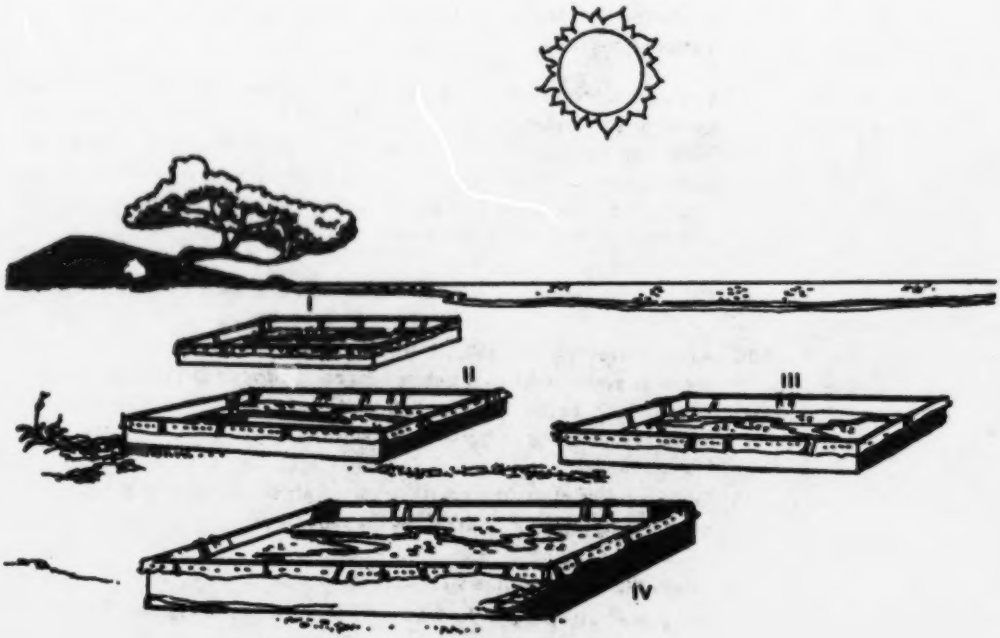
## MATERIALS:

Polyethylene plastic 1 m x 50 m, not thinner than gauge 6
bamboos or plastic pails
stapler and 1 box staple wire
lumber
bamboo basket
sand filter or finely woven cloth
waterproof plastic tape or silicon sealer or fish aquarium sealer

## PROCEDURE

1. **Location of Ponds**

Choose a place on the beach where sunlight falls on it most of the day.
Clear the place of any sharp objects that may cause holes on the plastic.



2. **Evaporating Ponds**

Prepare 4 wooden frames 1 m x 5 m x 15 cm. Line each with plastic material. Staple the plastic to the upper edges of the frame. Label the plastic ponds with the numbers I, II, III and IV.

3. **Crystallizing Ponds**

Build 2 crystallizing ponds 1 m x 3 m x 6 cm in the same way as the evaporating ponds.

4. Use plastic pails or good size bamboos to collect seawater.

5. Fill the evaporating ponds I to III with seawater. Keep pond IV empty to later store concentrated seawater from ponds I to III.

6. After 3 days transfer concentrated seawater from ponds I to III into pond IV. Fill ponds I to III with seawater. Allow the salt solution in pond IV to evaporate for another 3 days.

5. Filter the concentrated salt solution from pond IV twice before transferring to the crystallizing ponds. Transfer at late afternoon or early morning before the sun rises. Fill the ponds only to one-half its depth or about 3 cm. Do not add seawater to the crystallizing pond when salt is starting to form.

8. Every afternoon harvest the salt in the crystallizing ponds. Use your hands or soft nylon brush to push the salt to one corner of the pond. Take care not to make any holes in the nylon material. If holes are made, cover with waterproof plastic tape or silicon sealer or sealer used in fish aquariums. Pick up the salt and store in big bamboo baskets and allow to drip into a container.

9. Dry the salt under the sun for one or two days before storing in sacks.

10. After harvesting the salt, if the remaining liquid is whitish or thick throw it away or filter it before new concentrated salt solution is again added. It is better to discard the whitish liquid after harvesting salt twice as it contains carbonates and sulfates.

11. Once a week clean the crystallizing ponds by washing in the sea. The crystallizing ponds should be always kept clean.

12. When the rainy months start usually in May or June, carefully remove the plastic sheets from the frames. Roll them over bamboos. The plastic sheets may be used again on the next dry season.

SUGGESTIONS

1. If you cannot afford several ponds, you can allow salt to crystallize in the evaporating ponds. It will take longer for salt to appear, more than 7 or 8 days.

2. Keep a storage tank for concentrated seawater from the evaporating pond IV which can be covered in case of rain.

In fishing communities where cement is expensive and plastic is not available or too expensive, the following method can be followed to prepare salt for home use or for salting fish. The procedure given is for a single home consumption. For industrial production more and longer bamboo rafts may be used.

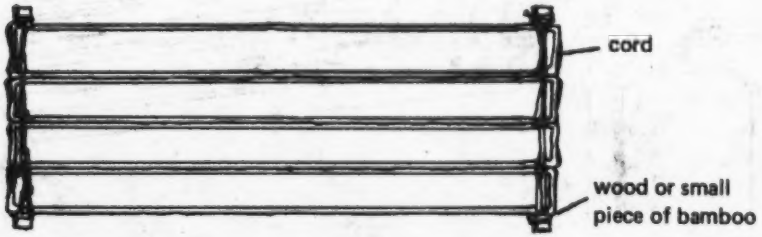
**Salt by Solar Evaporation of Seawater Using Bamboo Rafts**

MATERIALS

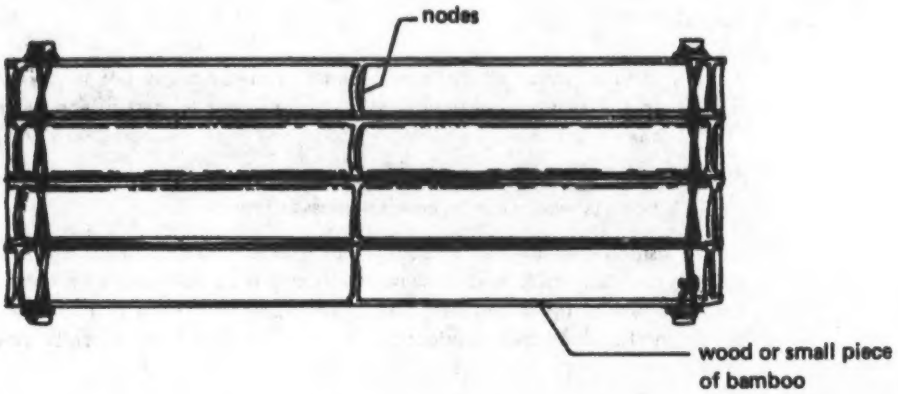
bamboos of 10 cm and 7 cm diameters
cord (rattan, bamboo or plastic)
plastic pail
measuring cup
flower pots and stand
light colored cloth
plastic or wooden scoop
bamboo scraper
bamboo basket or bilao

PROCEDURE

1. Prepare two bamboo rafts using bamboo halves. Figure A shows the evaporating raft made with the 10 cm diameter bamboo. The nodes in the middle are removed; B, the crystallizing raft build with the 7 cm diameter bamboo. In this raft the nodes are not removed.




(A) EVAPORATING RAFT

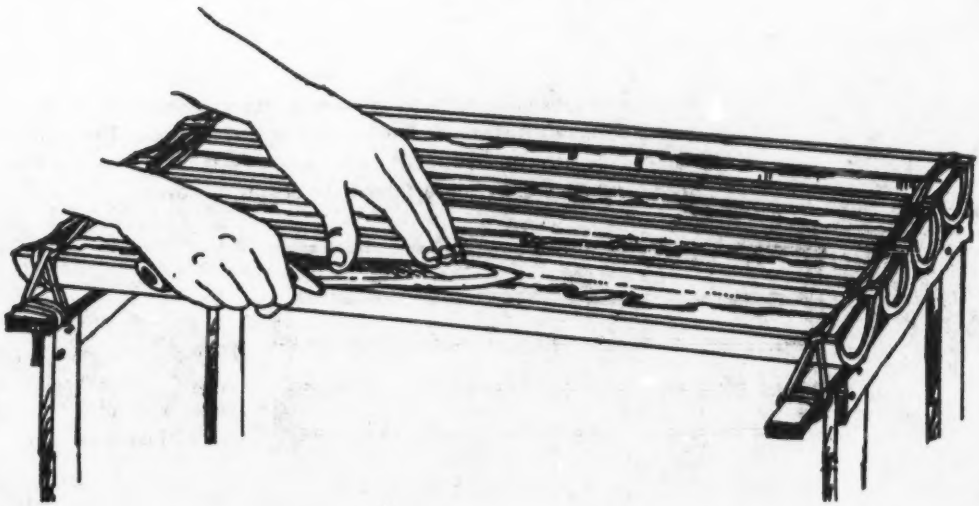



(B) CRYSTALLIZING RAFT

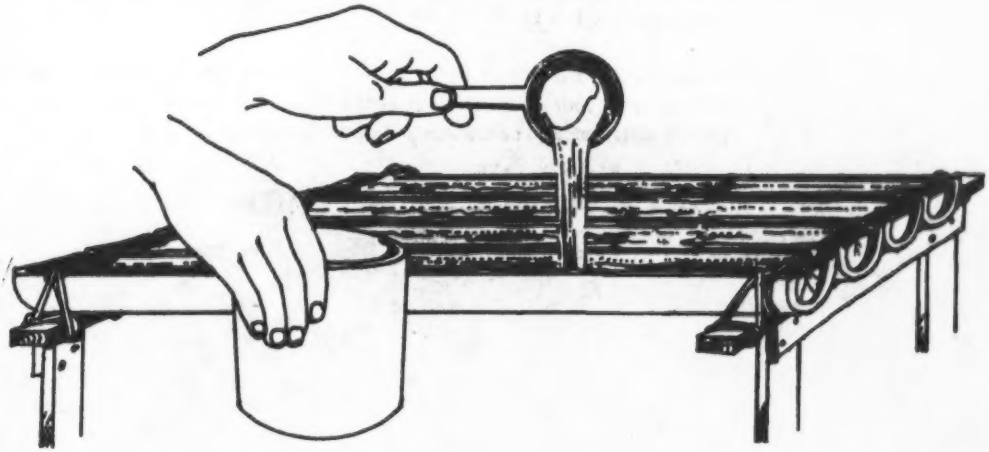
2. Support each raft one meter from the ground in a place receiving sun all day.

3. Using a banca and plastic (not metal) pails collect seawater far from the shore where the water is deep and clear.

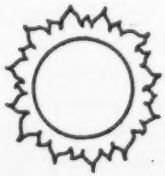
4. Pour one cup seawater into each bamboo half of raft A. Scratch a mark at the upper water level of each half.

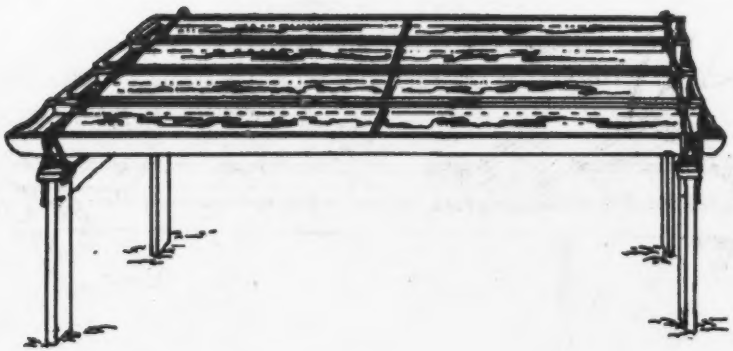


5. Using the measuring cup fill the bamboo halves with seawater. Record the number of cups in each half.



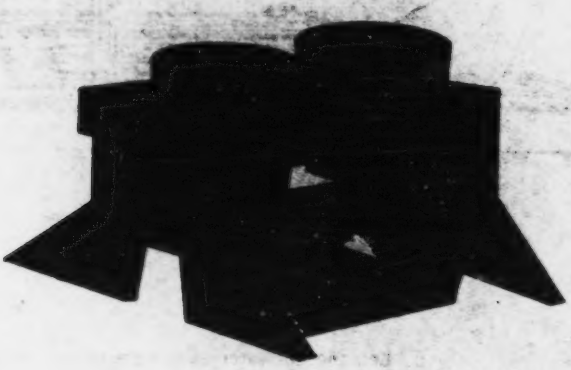
6. Let the seawater evaporate under the sun until the level is near the mark.





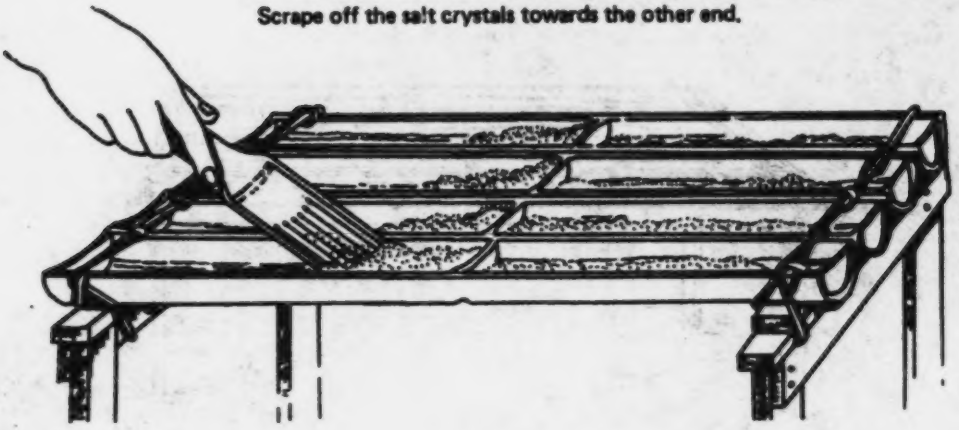
7. Again add seawater to fill the bamboo halves and record the number of cups added. See that you do not exceed a total number of 12 cups per bamboo half. Continue evaporating until the level is at the mark as in step 6. If you notice a white, scaly crystal or powder on top of the water scrape off or break the film.

8. Scoop out all the water. Filter through a set of flower pots used as funnels with four folds of cloth as the filter. The crystals are the less soluble salts, calcium carbonate and calcium sulfate.



9. Pour 1/2 cup of the filtrate into each division of the crystallizing raft B.

10. Allow to evaporate but not to dryness as the bamboo will crack. Soluble magnesium and calcium salts are also dissolved in the liquid portion. At the end of the day or before it dries up (at least 20 mL or 2 tsp of liquid still remain in each division), tilt one side of the raft using stone or wooden blocks to allow the remaining liquid to flow to one end. Scrape off the salt crystals towards the other end.



11. Remove and spread the crystals in a bilao and allow to drip in a shady place and leave it overnight. The next day place in the sun to dry completely.

12. Wash off the remaining liquid in the crystallizing raft. Fill with water when not in use to prevent cracking of the bamboo under the heat of the sun.

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